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US005237649A

**United States Patent** [19]

Yamada

[11] Patent Number: **5,237,649**[45] Date of Patent: **Aug. 17, 1993**

[54] **METHOD AND SYSTEM FOR ACQUIRING  
INTERPOLATION POINTS FROM  
STRAIGHT SHORT VECTORS  
REPRESENTING FIGURE IN CURVE  
FITTING**

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[21] Appl. No.: **511,736**

[22] Filed: **Apr. 20, 1990**

[30] **Foreign Application Priority Data**

Apr. 20, 1989 [JP] Japan ..... 1-100534

[51] Int. Cl. ..... G06F 15/72

[52] U.S. Cl. ..... 395/142; 395/141;  
395/143; 340/728; 340/747

[58] Field of Search ... 364/518, 521, 522, 200 MS File,  
364/900 MS File; 340/747, 750, 728; 382/46;  
395/141, 142, 143

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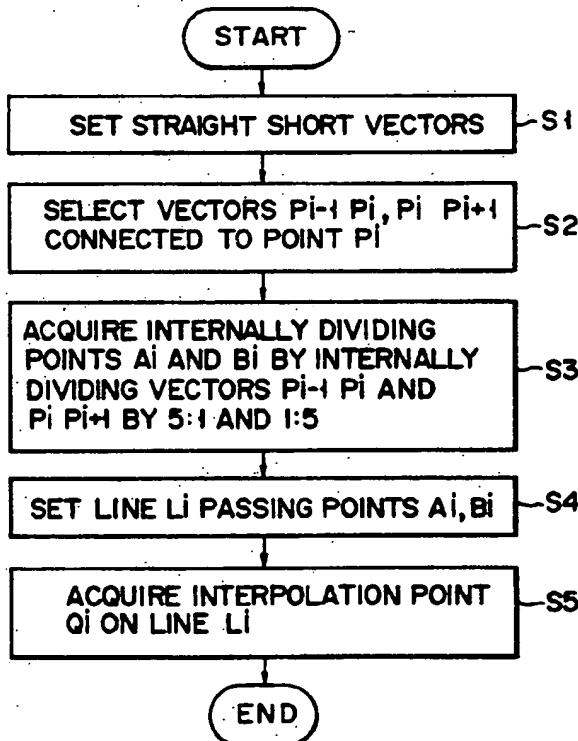
[57] **ABSTRACT**

In curve fitting for straight short vectors representing an original figure, an internally dividing point setting section sets, on two adjacent vectors, internally dividing points at which the vectors are divided internally in predetermined ratios. An interpolation point setting section sets the intersection of the straight line passing the internally dividing points of the two adjacent vectors and the perpendicular passing the connecting point of the two adjacent vectors as an interpolation point. In a curve-fitting process section, the curve fitting is performed on the basis of the acquired interpolation point.

**OTHER PUBLICATIONS**

"Conic B-splines for Curve Fitting: a Unifying Ap-

10 Claims, 7 Drawing Sheets



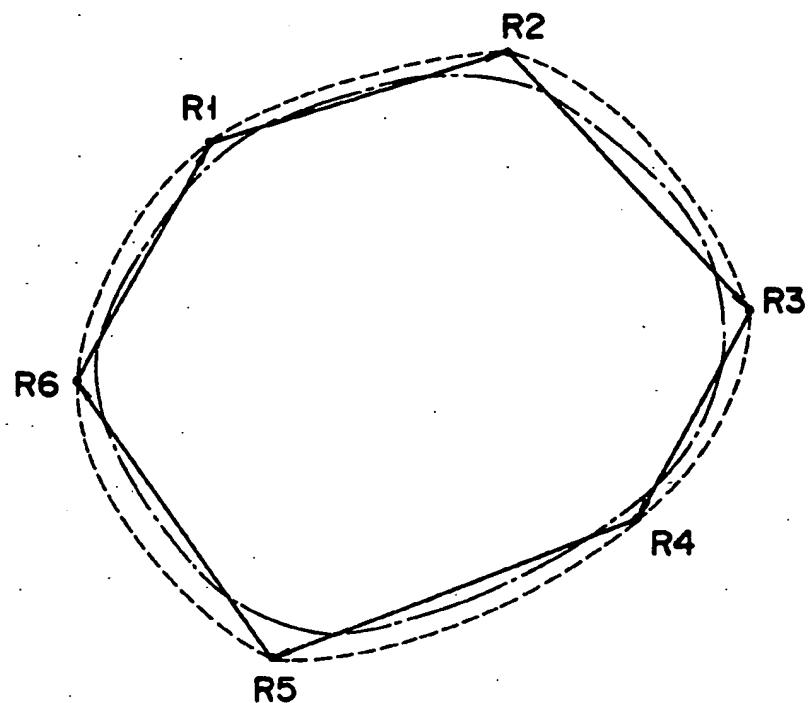


FIG. 1

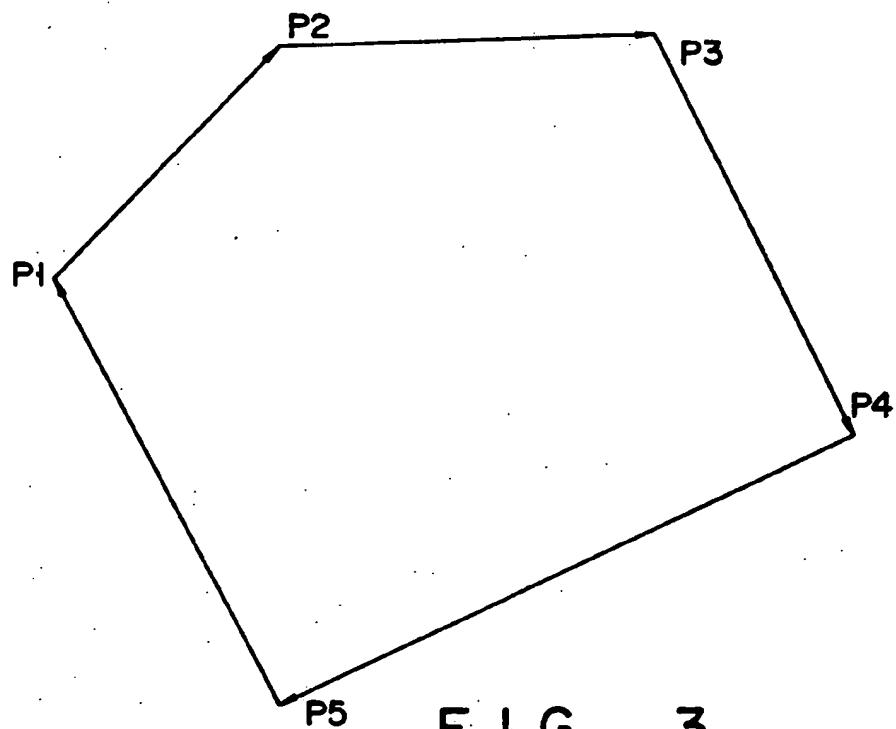
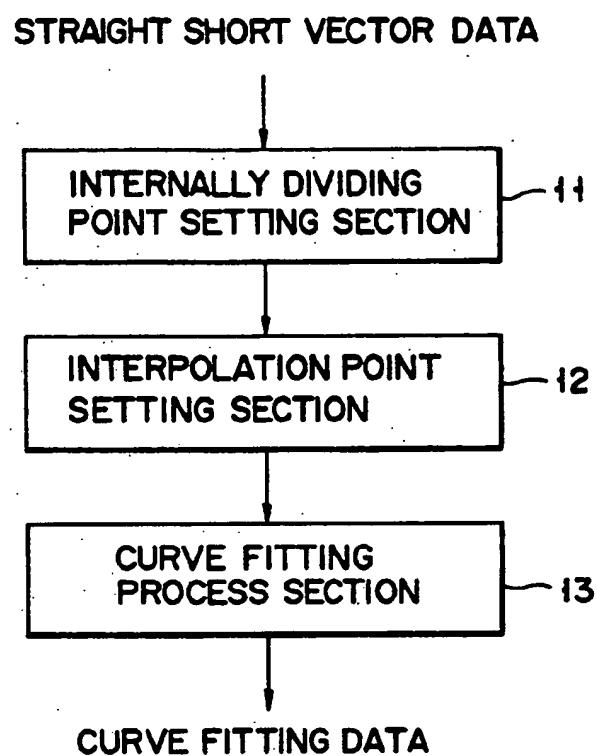


FIG. 3



F I G. 2

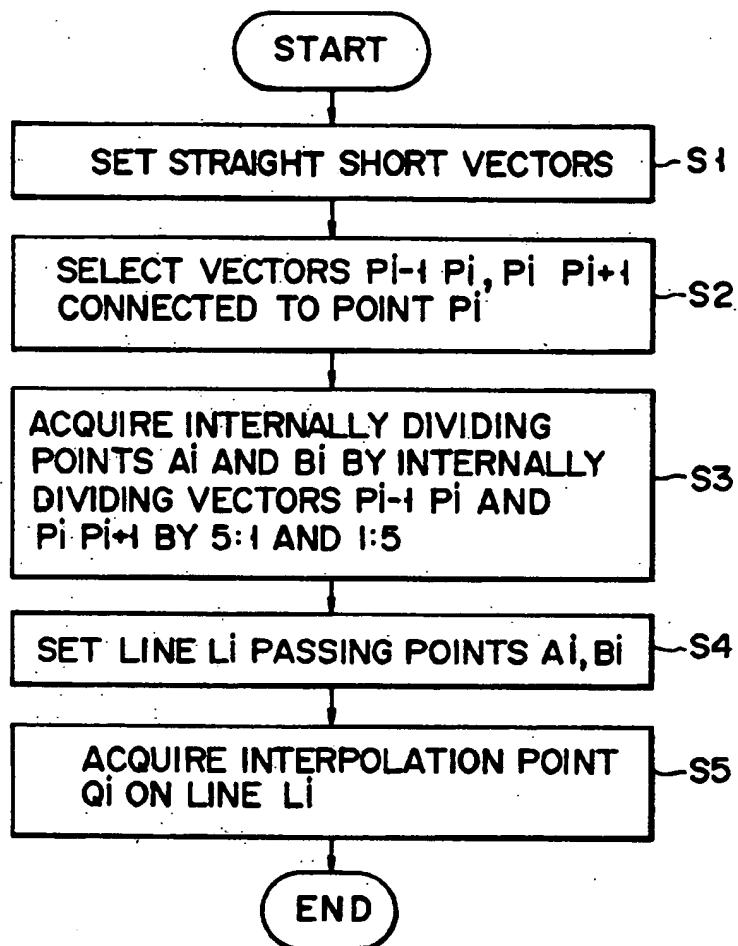
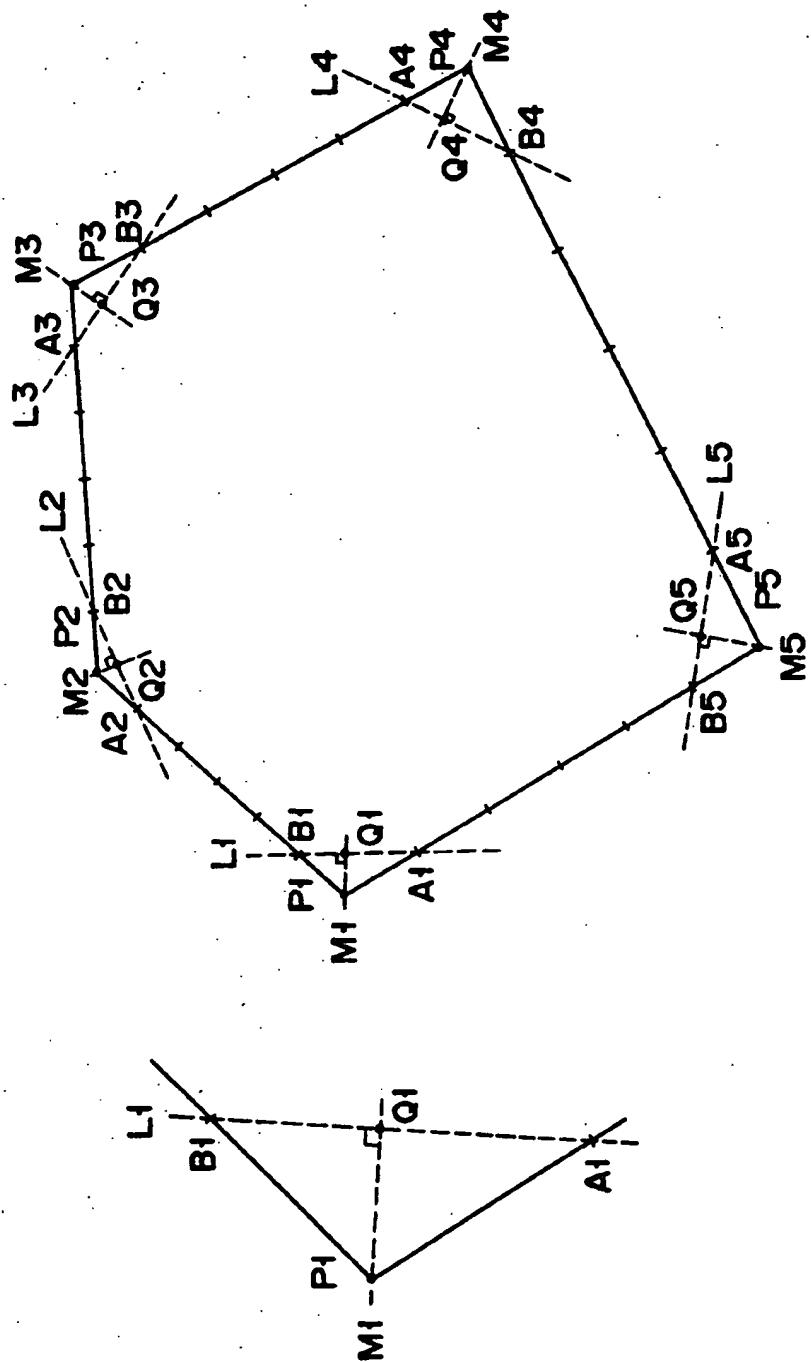
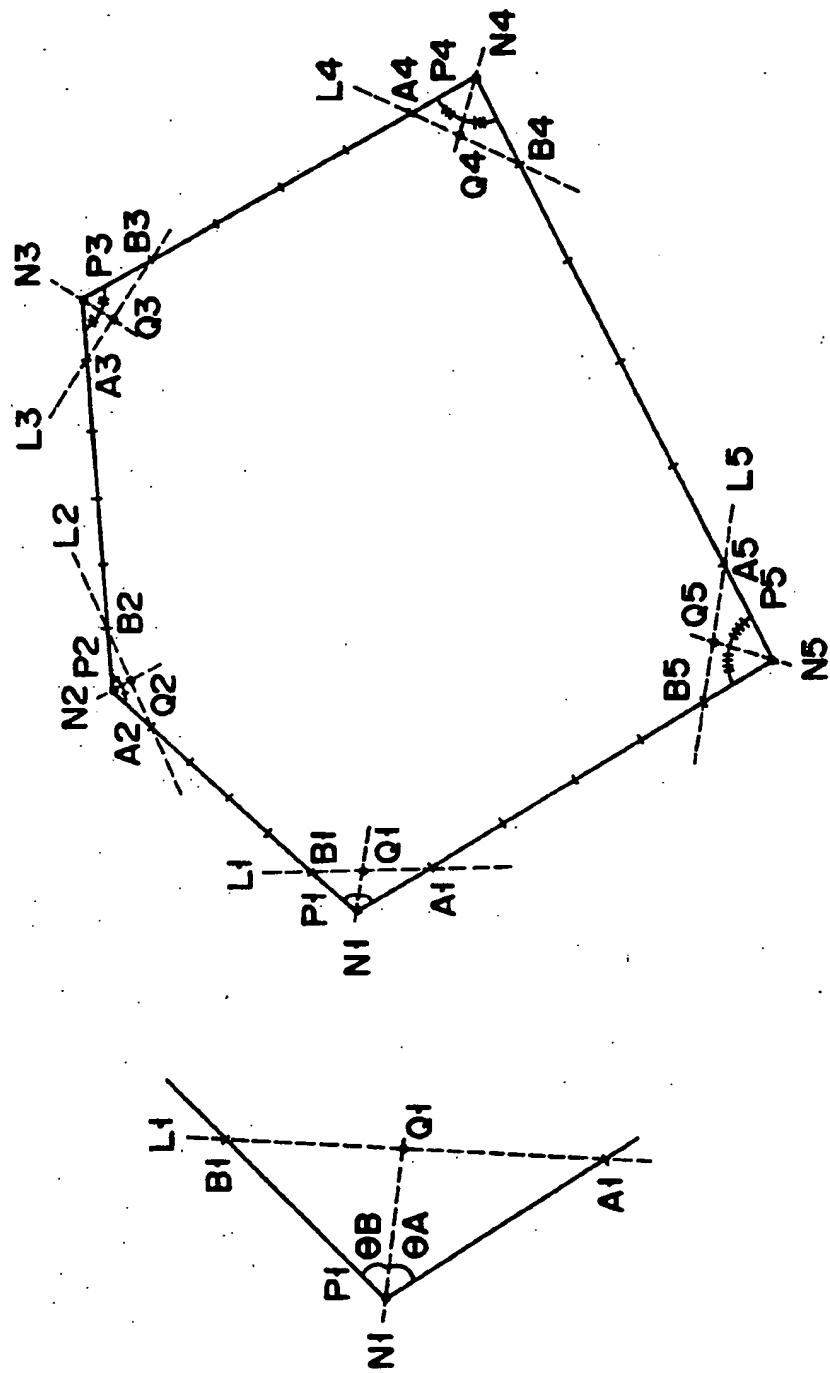


FIG. 4



F I G. 5A      F I G. 5B



F I G. 6A

F I G. 6B

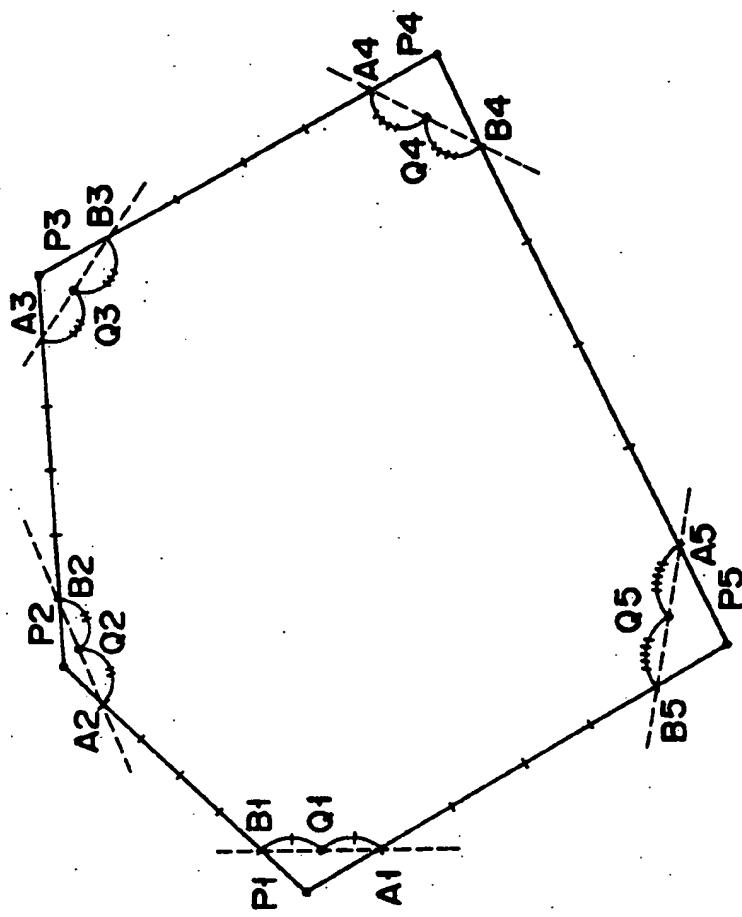


FIG. 7B

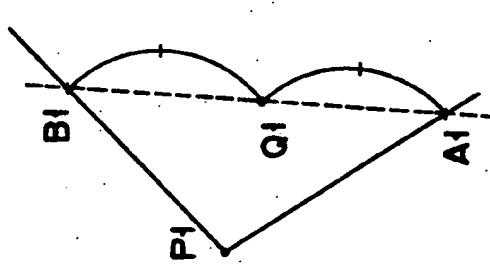


FIG. 7A

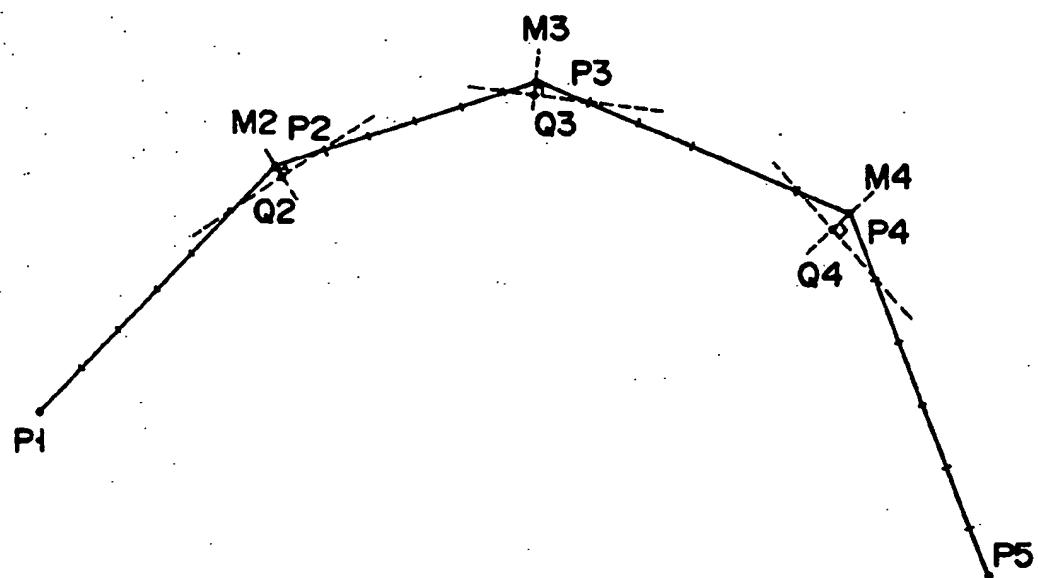


FIG. 8

**METHOD AND SYSTEM FOR ACQUIRING  
INTERPOLATION POINTS FROM STRAIGHT  
SHORT VECTORS REPRESENTING FIGURE IN  
CURVE FITTING**

**BACKGROUND OF THE INVENTION**

**1. Field of the Invention**

The present invention relates to a method and system for acquiring interpolation points from straight short vectors representing a figure.

**2. Description of the Related Art**

In obtaining outlines of characters and graphic forms in the field of computer graphics, computer aided design (CAD), generation of outline fonts and so on, a method is generally used which fits Bezier curves or B-spline curves to straight short vectors approximately representing an original figure.

When a plurality of straight short vectors (R1R2, R2R3, ... R5R6, R6R1, which are shown by solid lines) representing an original figure as shown in FIG. 1 are given, the fitting of a curve (which is indicated dashed) is performed so that it will pass connecting points R1 through R6 of the straight short vectors.

A problem will arise in that, although the straight short vectors approximately represent the original figure, the curve fitted to the straight short vectors is different from the original figure.

In view of the above, methods for curve fitting have been desired which can represent an original figure more accurately on the basis of straight short vectors.

**Summary of the Invention**

It is an object of the present invention to provide a method and system for acquiring interpolation points from straight short vectors representing a figure.

According to one aspect of the present invention, there is provided a method for acquiring interpolation points from straight short vectors representing a figure, each straight short vector being connected to a connecting point, the method comprising the steps of:

acquiring two internally dividing points by internally dividing lengths of two vectors of the straight short vectors into desired ratios;

setting a straight line passing the acquired two internally dividing points; and

acquiring the interpolation point on the set straight line.

According to another aspect of the present invention, there is provided a system for acquiring interpolation points from straight short vector representing a figure, each straight short vector being connected to a connecting point, the system comprising:

first acquiring means for acquiring two internally dividing points by internally dividing lengths of two vectors of the straight short vectors into desired ratios;

means for setting a straight line passing the acquired two internally dividing points; and

second acquiring means for acquiring the interpolation point on the set straight line.

Additional objects and advantages of the invention will be set forth in the description which follows, and in part will be obvious from the description, or may be learned by practice of the invention. The objects and advantages of the invention may be realized and obtained by means of the instrumentalities and combinations particularly pointed out in the appended claims.

**BRIEF DESCRIPTION OF THE DRAWINGS**

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate a presently preferred embodiment of the invention, and together with the general description given above and the detailed description of the preferred embodiment given below, serve to explain the principles of the invention.

FIG. 1 illustrates an example of curve fitting for straight short vectors;

FIG. 2 is a block diagram of a system embodying the present invention;

FIG. 3 illustrates straight short vectors to be processed in the present system;

FIG. 4 is a flowchart of the interpolation point acquiring process in the present system; and

FIGS. 5A, 5B, 6A, 6B, 7A, 7B and through 8 diagrams illustrating the method of acquiring interpolation points in the present system.

**DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT**

In FIG. 2, the present system is comprised of an internally dividing point setting section 11, an interpolation point setting section 12 and a curve fitting processing section 13.

Internally dividing point setting section 11 sets a point  $A_i$  at which a straight short vector  $P_i-1P_i$  ( $2 \leq i \leq n-1$ ) is divided internally in a ratio  $m-1 : 1$  and a point  $B_i$  at which a straight short vector  $P_iP_{i+1}$  is divided internally in a ratio of  $1 : m-1$  on the basis of straight short vector data.  $m$  is assumed herein to be 6.

Interpolation point setting section 12 sets a point  $Q_i$  on a straight line  $L_i$  passing internally dividing points  $A_i$  and  $B_i$  set by internally dividing point setting section 11.

Curve fitting process section 13 performs a process of fitting a curve to straight short vectors on the basis of interpolation point  $Q_i$  set by interpolation point setting section 12.

Next, the operation of the present system will be described.

In the present system, a process of fitting a curve to the straight short vectors as shown in FIG. 3 will be described with reference to the flowchart of FIG. 4. It is assumed that an original figure is indicated by straight short vector  $P1P2, P2P3, P3P4, P4P5$  and  $P5P1$ .

In step S1, straight short vector data are set in internally dividing point setting section 11.

In step S2, for example, a point  $P1$  is selected as the first process object.

In step S3, points  $A1$  and  $B1$  at which the lengths of straight short vectors  $P5P1$  and  $P1P2$ , which are connected to point  $P1$ , are divided internally in ratios of  $5 : 1$  and  $1 : 5$ , respectively, are acquired.

In step S4, in interpolation point setting section 12, a straight line  $L1$  passing internally dividing points  $A1$  and  $B1$  is set.

In step S5, an interpolation point  $Q1$  on straight line  $L$  is acquired as shown in FIG. 5A. It is assumed that interpolation point  $Q1$  is the intersection of straight line  $L1$  and the perpendicular  $M1$  passing connecting point  $P1$ .

By the above process each of interpolation points  $Q2$  through  $Q5$  corresponding to connecting points  $P2$  through  $P5$  of the straight short vectors is set. Interpolation points  $Q1$  through  $Q5$  are indicated in FIG. 5B.

As shown in FIG. 6A, the intersection of the straight line  $N_1$ , which bisects an angle formed by straight short vectors  $P_5P_1$  and  $P_1P_2$  at connecting point  $P_1$  such that  $\theta A = \theta B$ , and straight line  $L_1$  may be used as an interpolation point  $Q_1$ . Interpolation points  $Q_2$  through  $Q_5$  corresponding to connecting points  $P_2$  through  $P_5$  of the straight short vectors are set in a similar manner. Interpolation points  $Q_1$  through  $Q_5$  respectively corresponding to connecting points  $P_1$  through  $P_5$ , respectively are indicated in FIG. 6B.

In addition, as shown in FIG. 7A, the middle point of a line segment  $A_1B_1$  connecting internally dividing points  $A_1$  and  $B_1$  may be used as interpolation point  $Q_1$ . Interpolation points  $Q_2$  through  $Q_5$  corresponding to connecting points  $P_2$  through  $P_5$  of the straight short vectors are set in the similar manner. Interpolation points  $Q_1$  through  $Q_5$  respectively corresponding to connecting points  $P_1$  through  $P_5$  are indicated in FIG. 7B.

In the above description, the process of acquiring interpolation points for a closed straight short vector series is described. When a non-closed straight short vector series is given, as shown in FIG. 8, interpolation points corresponding to connecting points  $P_2$ ,  $P_3$  and  $P_4$  are set in the above manner and points  $P_1$  and  $P_5$  are used for interpolation points  $Q_1$  and  $Q_5$  corresponding to connecting points  $P_1$  and  $P_5$ .

In curve fitting process section 13, the curve fitting is performed on the basis of interpolation points  $Q_1$  through  $Q_5$  respectively corresponding to connecting points  $P_1$  through  $P_5$  of the straight short vectors, thereby obtaining curve fitting data. The curve-fitting method varies according to representation of a curve and the maximum allowable error for interpolation points. For example, a method of fitting a B-spline curve to pass each of interpolation points or a method of estimating the least square error may be used.

Also, the curve fitting using a Bezier curve based on interpolation points may be performed. With this curve fitting, the state of connection of curve segments must be taken into account. For this reason, the following method may be used. That is, an interpolation point  $Q_i$  on a straight line  $L_i$  passing internally dividing points  $A_i$  and  $B_i$  of straight short vectors  $P_{i-1}P_i$  and  $P_iP_{i+1}$  and the gradient  $\theta_i$  of straight line  $L_i$  are acquired. The gradient  $\theta_i$  of straight line  $L_i$  is the gradient at interpolation point  $Q_i$  (the first derivative at interpolation point  $Q_i$ ). The curve fitting using the Bezier curve is carried out on the basis of interpolation point  $Q_i$  and the gradient  $\theta_i$  at interpolation point  $Q_i$ .

As described above, interpolation point  $Q_i$  is set on straight line  $L_i$  passing point  $A_i$  to divide straight short vector  $P_{i-1}P_i$  internally in a ratio of  $m-1 : 1$  ( $m=6$  in the present embodiment) and point  $B_i$  to divide straight short vector  $P_iP_{i+1}$  internally in a ratio of  $1 : m-1$ . The curve fitting is performed by use of an interpolation point  $Q_1$ . For example, by performing the above curve fitting for the straight short vectors indicated by solid lines in FIG. 1, curve-fitting data indicating a figure that is represented by a dashed and dotted line more closely approximates the original figure.

The obtained curve-fitting data is used in the field of computer graphics, CAD and generation of outline fonts. For example, by fitting a curve to straight short vectors approximately representing a character pattern in accordance with the above method, an outline font close to an original figure can be obtained.

Additional advantages and modifications will readily occur to those skilled in the art. Therefore, the invention in its broader aspects is not limited to the specific details, representative devices, and illustrated examples shown and described herein. Accordingly, various modifications may be made without departing from the spirit or scope of the general inventive concept as defined by the appended claims and their equivalents.

What is claimed is:

1. A method for generating and displaying a curved image comprising the steps of:  
receiving an image in the form of straight short vectors, said straight short vectors corresponding to at least one curve segment;  
determining interpolation points of said straight short vectors, said interpolation points corresponding to connecting points of said straight short vectors, each of said connecting points being a point between two adjoining straight short vectors;  
fitting a curve to said straight short vectors using said interpolation points; and  
thereby generating a curved image in the form of said curve;  
wherein said interpolation points determining step includes the steps of for each one of said connecting points:  
acquiring two internally dividing points by internally dividing lengths of two vectors of said straight short vectors connected to one of said connecting points into desired ratios;  
setting a straight line passing through said acquired two internally dividing points; and  
thereby determining one of said interpolation points on said set straight line for said connecting point.
2. The method according to claim 1, wherein said curve includes a Bezier curve.
3. The method according to claim 1, wherein each of said interpolation points is a point of intersection between said set straight line and a line perpendicular to said set straight line which passes through said corresponding connecting point.
4. The method according to claim 1, wherein each of said interpolation points is a point of intersection between said set straight line and a straight line passing through said connecting point which equally divides an angle formed by two of said straight short vectors.
5. The method according to claim 1, wherein each of said interpolation points is a point in the middle of said set straight line.
6. A system for generating and displaying a curved image comprising:  
means for receiving an image in the form of straight short vectors, said straight short vectors corresponding to at least one curve segment;  
means for determining interpolation points of said straight short vectors, said interpolation points corresponding to connecting points of said straight short vectors, each of said connecting points being a point between two adjoining straight short vectors;  
means for fitting a curve to said straight short vectors using said interpolation points; and  
means for generating a curved image in the form of said curve in response to said fitting means;  
wherein said means for determining interpolation points for each one of said connecting points includes:

means for acquiring two internally dividing points by internally dividing lengths of two vectors of said straight short vectors connected to one of said connecting points into desired ratios;

means for setting a straight line passing through said acquired two internally dividing points; and second means for determining one of said interpolation points on said set straight line for said connecting point;

7. The system according to claim 6, wherein said curve fitting means includes means for fitting a Bezier curve to said straight short vectors.

8. The system according to claim 6, wherein said second interpolation point determining means includes means determining said interpolation point to be a point

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of intersection between said set straight line and a line perpendicular to said set straight line which passes through said corresponding connecting point.

9. The method according to claim 6, wherein said second interpolation point determining means includes means determining said interpolation point to be a point of intersection between said set straight line and a straight line passing through said connecting point which equally divides an angle formed by two of said straight short vectors.

10. The method according to claim 6, wherein said second interpolation point determining means includes means determining said interpolation point to be a middle point of said set straight line.

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